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FINAL REPORT ON LONG-TERM TESTING OF SLUDGE WASH CEMENT-WASTE FORM

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Prepared by: M. N. Baker

M. N. Baker, Cognizant Engineer — Date 11/4/96

Approved By:

R. J. Fussner, IRTS Operations Manager — Date 11/6/96

D. C. Meess, Cognizant System Design Manager — Date 12/3/96

J. P. Hummel, Quality Assurance Manager — Date 11/6/96

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FINAL REPORT ON LONG-TERM TESTING OF SLUDGE WASH CEMENT-WASTE FORM

Rev. 1

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FINAL REPORT ON LONG-TERM TESTING OF SLUDGE WASH CEMENT-WASTE FORM

Rev. 1

LIST OF ABBREVIATIONS AND ACRONYMS

CFR	Code of Federal Regulations
CSS	Cement Solidification System
DOE	United States Department of Energy
EPA	United States Environmental Protection Agency
HLW	High Level Waste
IRTS	Integrated Radwaste Treatment System
LLW	Low Level Waste
LWTS	Liquid Waste Treatment System
NRC	United States Nuclear Regulatory Commission
PCP	Process Control Plan
PPM	Parts-per-million
Std. Dev.	Standard Deviation
TCLP	Toxicity Characteristic Leach Procedure
TDS	Total Dissolved Solids
TP	NRC Technical Position on Waste Form
W/C	Water-to-Cement weight ratio
WDV	Waste Dispensing Vessel
wt.% TDS	Weight Percentage of the Total Dissolved Solids
WVDP	West Valley Demonstration Project
WVNS	West Valley Nuclear Services Co., Inc.
WVNS-TPL	West Valley Nuclear Services Test Plan
WVNS-TR	West Valley Nuclear Services Test Report

WVNS-TR-70-027

FINAL REPORT ON LONG-TERM TESTING OF SLUDGE WASH CEMENT-WASTE FORM

Rev. 1

1.0 SUMMARY

This document is presented by West Valley Nuclear Services Co., Inc. (WVNS) to provide the technical information on the long-term testing on the stabilized Sludge Wash Class A cement-waste form that was produced at the West Valley Demonstration Project (WVDP). The information contained herein demonstrates compliance with the requirements for radioactive low-level waste (LLW) as set forth in 10 CFR 61 and the Nuclear Regulatory Commission (NRC) Branch Technical Position on Waste Form, Reference 1. The test results and criteria are summarized in Table 1. The long-term testing has verified that the cement-waste retains compressive strength and structural integrity.

2.0 BACKGROUND

The West Valley Demonstration Project Act of October 1, 1980 (Public Law 96-368), directs the Department of Energy (DOE) to carry out a radioactive high-level waste (HLW) management demonstration project at the West Valley, New York site. The West Valley site was the location of the only operating commercial nuclear fuel reprocessing plant in the United States. West Valley Nuclear Services Co., Inc., a subsidiary of Westinghouse Electric Corporation, has been the prime contractor to DOE for site operations since 1982.

The demonstration project is removing HLW from underground storage tanks and solidifying it into a borosilicate glass for long-term storage at a future federal repository. The major portion of the HLW amounted to about 2 million liters of liquid stored in an underground storage tank, designated Tank 8D-2.

Prior to HLW stabilization in borosilicate glass, several pretreatment operations were defined that would minimize the final volume of HLW glass. Beginning in 1988, WVNS processed the liquid supernatant solution (Table 2) from Tank 8D-2 through an ion-exchange process to yield a LLW solution. The LLW stream was concentrated and made into a cementitious waste form. The resulting Class C cement-waste is described in a previous topical report, "Cement Waste Form Qualification Report - WVDP PUREX Decontaminated Supernatant." Supernatant Processing operations were performed from May 1988 through November 1990, with 618,300 gallons of supernatant liquid processed from Tank 8D-2 resulting in 10,394 cement-waste drums. The final report on the short and long-term testing of this waste form is included in Test Report WVNS-TR-70-026 (Reference 3).

The next pretreatment step was implemented at the WVDP in 1992. The HLW in 8D-2 was mobilized by 5 mixing pumps, which allowed the sodium sulfate crystals to dissolve into sludge wash water added to the tank. By adding caustic during the sludge washing operation, uranium, strontium, and plutonium were maintained at trace levels in the sludge wash solution.

The resulting sludge wash solution was treated in the ion-exchange process as was done with the previous supernatant solution. A new ion-exchange zeolite was used to retain cesium, strontium, and plutonium from the sludge wash solution. The resulting LLW stream was concentrated and made into a cementitious form in the Cement Solidification System (CSS) similar to the supernatant waste.

Initial operation began with stabilization in Portland Type I cement, similar to the supernatant recipe. In order to meet NRC stability requirements, the waste concentration was reduced from nominally 39% Total Dissolved Solids (TDS) for the supernatant waste stream to 20% TDS for the sludge wash waste stream. The Type I qualification report is Reference 4.

Later, the decontaminated sludge wash waste stream was processed using Portland Type V cement, and higher waste loadings up to 33% TDS with improved sulfate resistance. The Type V waste form qualification report is reference 5. Table 1 presents the difference between the Type I and Type V recipes.

This report includes the results of testing of cores obtained from CSS (Cement Solidification System) production drums processed in May (using Type I cement) and September 1993 (using Type V cement) and cured 198 to 1235 days.

3.0 SLUDGE WASH CEMENT-WASTE FORM TESTING

The long-term test program, under WVNS-TP-062 for Type I cement recipes and WVNS-TP-63 for Type V recipes, required core-boring of CSS production drums to verify compliance with 10 CFR 61 criteria and the NRC Branch Technical Position acceptance criteria. Testing was performed for compressive strength. Compressive strength testing after 14 days immersion in synthetic seawater was performed at the 6-month and 12-month intervals.

Both long-term test programs were performed to demonstrate long-term (3-year) compressive strength and minimal cracking and spalling. The long-term test programs required twenty drums to be selected from a single production run and subjected to periodic testing over three years. After an initial cure period of six months, six cores were taken from the first long-term test drum: two from the upper, middle, and lower sections of the drum. Upon completion of a visual examination, one core from each level of the drum was destructively evaluated for compressive strength per ASTM C-39. The remaining cores were bagged and stored in the Drum Cell environment (controlled to > 50°F) for examination at six-month intervals for signs of cracking or spalling. For drums 2 through 6, as with drum 1, the tests were repeated in their entirety every six months (approximately). The remaining 14 drums not tested are stored in the Drum Cell for possible future tests.

3.1 Core-boring Technique

All cores were obtained through the side of the drum with the drum horizontal. Drilling was performed essentially dry, using only 1 to 2 ounces of water occasionally to cool the bit. After the core bit penetrates the drum approximately 6 to 8 inches, the bit is removed and the core is broken off near the bottom by inserting tooling into the kerf and using one of three techniques to snap off the core. Often cores removed have a transverse break across the fractured end which is then sawed off to maintain a right cylindrical specimen.

Cores were measured and cut to a maximum length of 2 diameters plus one-quarter inch. This geometry is required by ASTM C-39 (Reference 2). The ends of the samples were saw cut square if necessary and sulfur capped to assure that they are parallel and to provide an equal bearing surface for compression testing.

Some fixture and hardware improvements were implemented during the coring process with positive results. Alternative methods and techniques for sampling and removing the cores were evaluated to minimize hairline fractures and unnecessary stresses during future coring operations. Cores with minor surface cracks were not otherwise deteriorated, indicating that the cause of the cracks and chips was not due to the sulfate or adverse chemical reaction within the cement-waste matrix.

3.2 Compressive Strength

Criteria: Long-term testing shall be performed to determine the compressive strength increase with time to ensure that the specimens have maintained compressive strength.

Waste Form: Test cores (2-3/4" diameter x 3" to 6" length) were removed from six full-scale drums prepared during Sludge Wash processing with solutions at nominal 20 wt.% TDS, using Type I cement and water-to-cement (W/C) ratios of 0.64 to 0.68 following a 198-day minimum cure time.

Six other drums prepared at nominally 30% TDS, with Type V cement and W/C ratios of 0.50 to 0.61 were also tested.

Tests: The cores were capped in accordance with ASTM Standard C-39. Compressive strength was measured with a Forney FT-40-DR Hydraulic Compression Unit. A total of 43 cores, from 12 drums, were crushed per ASTM-C39 to determine the compressive strength. Cores were obtained from the top, middle, bottom sections of each drum.

Type I Results: Table 3 is a summary of the compressive strength versus cure time for the six long-term drums all prepared at a nominal 20 wt% TDS and 0.67 water-to cement ratio. The average compressive strength of cores obtained from each of the sludge wash liquid drums ranged from 1,310 to 2,120 psi. Figure 1 is a graph of this data. As shown in Table 3 and Figure 1, the average compressive strengths of all cores from the long-term drums of cement-waste exceed the 1,102 psi minimum value.

Type V Results: Table 3 is a summary of the compressive strength versus time for the 6 long-term drums, all prepared at a nominal 32.2 wt% TDS and a 0.51 water-to-cement ratio. The average compressive strength of the cores ranged from 983 to 1,740 psi. Figure 2 is a graph of this data. As shown in Table 3 and Figure 2, the average compressive strengths of all cores from the long-term drums of cement-waste exceed the 848 psi minimum valve.

Conclusion: The average core compressive strength is well in excess of the requirement and the results demonstrate that compressive strength is maintained over a three year period.

3.3 Visual Examination of Archive Core

Criteria: Examine cores visually for any signs of cracking, spalling or degradation.

Waste Form: Cores were bagged and stored in the Drum Cell environment (controlled to > 50°F) for examination at six-month intervals for signs of cracking or spalling.

Tests: Upon completion of the initial visual examination, the cores were bagged and stored in the Drum Cell environment (controlled to > 50°F) for examination at six-month intervals for signs of cracking or spalling.

Type I Results: Visual examination of three cores obtained in March 1994 from drum 85425 after 307 days cure reveal that the cores remain in good condition throughout the long-term test period. No change was noted since the initial examination.

Visual examination of three cores obtained in September 1994 from drum 85396 after 503 days cure reveal that the cores remain in good condition throughout the long-term test period. No change was noted since the initial examination.

Visual examination of three cores obtained in March 1995 from drum 85499 after 677 days cure reveal that the cores remain in good condition throughout the long-term test period. No change was noted since the initial examination.

Visual examination of three cores obtained in September 1995 from drum 85474 after 859 days cure reveal that the cores remain in good condition throughout the long-term test period. No change was noted since the initial examination.

Visual examination of three cores obtained in March 1996 from drum 85461 after 1049 days cure revealed that the cores remain in good condition throughout the long-term test period. There was no change noted since the initial examination.

Drum 85410 was core-bored in September 1996, approximately 1235 days after processing. This initial and only visual examination of the cores was performed and showed that the cores were in good condition and free of any cracks and spalling defects.

Type V
Results:

Visual examination of three cores obtained in March 1994 from drum 88124 after 198 days cure revealed that the cores remain in good condition throughout the long-term test period. There was no change noted since the initial examination.

Visual examination of three cores obtained in September 1994 from drum 88134 after 393 days cure revealed that the cores remain in good condition throughout the long-term test period. There was no change noted since the initial examination.

Visual examination of three cores obtained in March 1995 from drum 88114 after 567 days cure revealed that the cores remain in good condition throughout the long-term test period. There was no change noted since the initial examination.

Visual examination of three cores obtained in September 1995 from drum 88106 after 748 days cure revealed that the cores remain in good condition throughout the long-term test period. There was no change noted since the initial examination.

Visual examination of three cores obtained in March 1996 from drum 88089 after 939 days cure revealed that the cores remain in good condition throughout the long-term test period. There was no change noted since the initial examination.

Drum 88116 was core-bored in September 1996, approximately 1126 days after processing. This initial and only visual examination of the cores was performed and showed that the cores were in good condition and free of any cracks and spalling defects.

Conclusion: Long-term testing 6-month interval visual inspections have shown that the cores do not degrade, crack or spall over a three-year test period. The initial baseline examination of the cores archived is provided in Table 4. The cement-waste form meets the stability criteria.

3.4 Immersion Resistance:

Criteria: Waste specimens shall be obtained at the 6-month and 12-month intervals and immersed for 14 days in synthetic seawater. Visual examination of the immersed samples shall be performed to verify no significant degradation (e.g., cracking or spalling). The average compression strength after immersion shall be greater than the qualification mean minus 2 standard deviations (1,102 psi for Type I cement-waste and 848 psi for Type V cement-waste.)

Waste Form: Cores were obtained from full-scale cement-waste drums 85425 produced with decontaminated sludge wash liquid and type I cement, and drum 88124 produced with decontaminated sludge wash liquid and type V cement.

After approximately 6-months cure, cores were obtained from full-scale cement-waste drums 85425 (type I cement) and drum 88124 (type V cement).

After approximately 12-months cure, cores were obtained from full-scale cement-waste drums 85396 (type I cement) and drum 88134 (type V cement).

Tests: The immersion test used laboratory ambient temperature and a nominal immersion liquid volume-to-core surface area ratio of 10 cm. One core from the cement-waste drum was suspended in a 1-gallon bucket for the immersion test. The cores were destructively evaluated for compressive strength per ASTM C-39.

Results: After 14 days of immersion in synthetic seawater the core specimen from drum 85396 showed only a 1/8" thick crust. The core from drum 88134 after 14 days immersion in synthetic seawater had a white chalky film, and spalling around the edges. Compressive strengths of the cores after immersion were 1100 psi (drum 88124 - 224 days cure), 1720 psi (drum 85425 - 348 days cure), 1070 psi (drum 88134 - 419 days cure), and 1770 psi (drum 85396 - 530 days cure). The 14-day immersion test results are summarized in Table 8.

Conclusion: The surface crust or film observed on 2 of the 4 cores do not constitute "significant cracking, spalling, or bulk disintegration." There were no cracks. The high compressive strengths of these cores indicate that the thin coating formed on the cores during the immersion period is clearly not detrimental to the core strength.

The sludge wash liquid cement-waste product exhibits excellent immersion resistance performance. All immersion core compressive strengths were greater than the required minimum strengths of 1,102 psi and 848 psi for the Type I and Type V cement wastes, respectively. The sludge wash liquid cement-waste passes the immersion test criteria.

3.5 Additional Tests:

Criteria: For both Type I and Type V cement recipes, waste specimens shall be obtained from a drum representing the waste batches with the **lowest** Process Control Plan cube compressive strengths and subjected to compressive strength testing. In addition, one core shall be immersed for 14 days in the qualification immersion liquid (synthetic seawater). Visual examination of the immersed samples shall be performed to verify no significant degradation (e.g., cracking or spalling). The average compression strength after immersion shall be greater than 1,102 psi for the Type I cement-waste and 848 psi for the Type V cement-waste.

Waste Form: Cores were obtained from drum 82207, produced with decontaminated sludge wash liquid and Type I cement and drum 90435, produced with decontaminated sludge wash liquid and Type V cement.

Tests: One core each (one each from the upper, middle, and lower section of the cement-waste drums) were destructively evaluated for compressive strength per ASTM C-39. In addition, one core from the lower section of the cement-waste drum was subjected to a 14-day immersion test in synthetic seawater.

Type I
Results: The average compressive strength of the three cores from drum 82207 (Type I) was 1640 psi. After 14 days of immersion in synthetic seawater, the core specimen from drum 82207 showed no signs of deterioration, and exhibited a compressive strength of 1980 psi.

Type V
Results: The average compressive strength of the three cores from drum 90435 (Type V) was 1710 psi. After 14 days of immersion in synthetic seawater, the core specimen from drum 90435 showed hairline cracks at the top and bottom, but no signs of gross deterioration, and exhibited a compressive strength of 1140 psi.

Conclusion: The core compressive strengths and the post-immersion strengths exceed the required minimum strengths.

3.6 Special NRC-Requested Test:

Criteria: For Type V cement recipes, waste specimens shall be obtained from a drum representing 20% TDS concentrates during Sludge Wash 2 and subjected to compressive strength testing. In addition, one core shall be immersed for 14 days in synthetic seawater. Visual examination of the immersed samples shall be performed to verify no significant degradation (e.g., cracking or spalling). The average compression strength after immersion shall be greater than 848 psi.

Waste Form: After curing 651 days, cores were obtained from drum 86764, produced with decontaminated sludge wash liquid and Type V cement.

Tests and Results: One core each (one each from the upper, middle, and lower section of the cement-waste drums) were destructively evaluated for compressive strength per ASTM C-39.

The average compressive strength of the three cores from drum 86764 (Type V) was 1613 psi. This data is illustrated in Figure 2. After 14 days of immersion, the core specimen from drum 86764 showed only surface porosity, but no cracks or other signs of deterioration, and exhibited a compressive strength of 970 psi, above the established 848 psi minimum criterion, but lower than the 1613 psi average of unimmersed cores.

4.0 CONCLUSIONS

The results of the three year long-term test program demonstrate that the CSS product drums made during sludge wash processing meet or exceed the NRC's Branch Technical Position on Waste Form requirements existing during the time of sludge wash processing.

The long-term test plan samples demonstrated that the cement compressive strength is maintained and that there is no degradation, cracking or spalling caused by aging. Extra NRC requested, immersion test criteria have been met.

Type I The plot of compressive strength versus time (Figure 1) shows that the Type I product continues to perform well, with an average compressive strength of 1773 psi for all long-term testing (including 1 additional test) as the product cures through 3 years. This average remains well above the minimum compressive strength criteria of 1102 psi.

Type V The plot of compressive strength versus time (Figure 2) shows that the Type V product continues to perform well, with an average compressive strength of 1326 psi for all long-term testing (including 2 additional tests) as the product cures through 3 years. This average remains well above the minimum compressive strength criteria of 848 psi.

No additional testing is planned on the sludge wash cement-waste drums.

5.0 REFERENCES

1 "NRC Branch Technical Positi.. on Waste Form Qualification," US Nuclear Regulatory Commission, Revision 1, January 1991.

2 ASTM C-39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

3 WVNS-TR-70-026, Final Report on Long-Term testing of Supernatant Cement-Waste Form," December 21, 1995.

4 WVNS-TP-70-024, "Waste Form Qualification Report: WVDP Stabilized Sludge Wash Cement-Waste With Type I Portland Cement," 1994.

5 WVNS-TP-70-023, "Waste Form Qualification Report: WVDP Stabilized Sludge Wash Cement-Waste With Type V Portland Cement," July 1994.

6 WVDP:0003205.RM, "Sampling and Analysis Plan/Quality Assurance Project Plan for West Valley Demonstration Project CSS Cement Waste Form," WVDP-211, Revision 0, dated October 27, 1994.

7 WVNS-PCP-002, "Process Control Plan for Cement Solidification of Sludge Wash Liquid," 1992.

8 WVNS-PCP-004, "Process Control Plan for Cement Solidification of Decontaminated Sludge Wash Liquid Using Type V Cement," 1993.

TABLE 1

SUMMARY OF WASTE FORM TESTING
WVDP STABILIZED SLUDGE WASH LIQUID CEMENT-WASTE (a)

Recipe	Type I	Type V
Waste Form Qualification Report	WVNS-TR-70-024	WVNS-TR-70-023
% Solids, Wt.% TDS	19-21 Wt.% TDS	19-33 Wt.% TDS
pH	>12.0	≥12.0
SO_4 (% total salts)	< 0.11 gram /gram salt	< 0.115 gram/gram salt
TECHNICAL POSITION ON WASTE FORM REQUIREMENT		
Compressive strength greater than the qualification sample average strength minus 2 times the standard deviation	all cores > 1102 psi	all cores > 848 psi
Requirement Pass/Fail	Pass	Pass
Compressive strength following 14-day immersion greater than the qualification sample average strength minus 2 times the standard deviation	> 1102 psi	> 848 psi
Requirement Pass/Fail	Pass	Pass

(a) All testing was performed on cores extracted from full-scale cement-waste drums produced in the Cement Solidification System.

TABLE 2

CHEMICAL COMPOSITION
OF TANK 8D-2 SUPERNATANT SOLUTION
COMPARED TO SLUDGE WASH LIQUID

	Supernatant	Sludge Wash
Major Constituents (wt % solids)		
Sodium	31	31
Nitrates	41	27
Nitrites	18	22
Sulfates	4.6	14
Carbonates	2.8	2.6
Minor Constituents (wt % solids)		
Potassium	1.42	0.85
Aluminum	0.03	0.21
Chlorine	0.25	0.15
Boron	0.003	0.0037
Phosphorus	0.06	0.057
Chromium	0.12	0.15
pH	10	>12
Wt % solids	39	19-33

Compositions expressed in dry weight percent (wt.% dry)

TABLE 3

SUMMARY OF COMPRESSIVE STRENGTH RESULTS

DRUM #	DATE PROCESSED	CURE TIME	CORE DESIGNATION	COMPRESSIVE STRENGTH
LONG-TERM TEST CORES: Type I Cement				
85425	05/13/93	307 days	C - top B- middle A - bottom	2130 psi 1850 psi 2380 psi 2120 psi avg
85396	05/13/93	503 days	A - bottom D - middle G - top	1520 psi 1310 psi 1630 psi 1490 psi avg
85499	05/13/93	677 days	A - bottom D - middle G - top	1320 psi 1950 psi 670 psi 1310 psi avg
85474	05/13/93	859 days	A - top C - middle F - bottom	2530 psi 1040 psi 2010 psi 1860 psi avg
85461	5/13/93	1049 days	H - top F - middle A - bottom	1620 psi 2120 psi 1620 psi 1920 psi avg
85410	05/14/93	1235 days	B - top E - middle F - bottom	2390 psi 1790 psi 2020 psi 2070 psi avg

TABLE 3 (Continued)

SUMMARY OF COMPRESSIVE STRENGTH RESULTS

DRUM #	DATE PROCESSED	CURE TIME	CORE DESIGNATION	COMPRESSIVE STRENGTH
LONG-TERM TEST CORES: Type V Cement				
88124	09/01/93	1?8 days	C - top D - middle G - bottom	990 psi 960 psi 1000 psi 983 psi avg
88134	09/01/93	393 days	G - top D - middle C - bottom	1080 psi 1170 psi 1010 psi 1090 psi avg
88114	09/01/93	567 days	C - top D - middle F - bottom	990 psi 1150 psi 1190 psi 1110 psi avg
88106	09/01/93	748 days	B - top D - middle F - bottom	1460 psi 850 psi 1040 psi 1120 psi avg
88089	09/01/93	939 days	B - top D - middle F - bottom	1630 psi 1790 psi 1780 psi 1740 psi avg
88116	09/01/93	1126 days	B - bottom D - middle F - top	1310 psi 1350 psi 1060 psi 1240 psi avg

TABLE 4
BASELINE EXAMINATION OF CORES ARCHIVED (TYPE I)

	Drum 85425			Drum 85396		
Cure Period	307 Days			503 days		
Core I.D.	D	F	G	C	E	H
length (inches)	≈ 7"	≈ 7"	≈ 6 3/4"	≈ 7¼"	≈ 7 3/8"	≈ 6"
cracks	half the length	none	none	none	none	none
surface porosity	minor	soft, pock marks, darker than adjacent material	minor	little	little	little
core condition	good	good	good	good	good	good
other notes	light grey	light grey	light grey	light grey, uniform color	light grey, uniform color	light grey, uniform color
	Drum 85499			Drum 95474		
Cure Period	677 days			859 days		
Core I.D.	C	F	I	B	D	F
length (inches)	≈ 4 1/2"	≈ 3 3/4"	≈ 3 1/2"	≈ 6"	≈ 5 3/8"	≈ 5 5/8"
cracks	none	none	none	none	none	none
surface porosity	at center	minor	minor	minor	minor	minor
core condition	good	good	good	good	good	good
other notes	large chip @ top, lt grey w/ dk grey areas, crumbly bottom	light grey w/ dark grey spots, large porosity @ center of core	dk grey @ bottom, porosity @ sides & bottom crumbly @ end	light grey, small dark spots	light to medium grey marbled, small dark spots	light grey, small dark grey spots, chips @ bottom

TABLE 4 (Continued)

BASELINE EXAMINATION OF CORES ARCHIVED (Type I)

	Drum 85461			Drum 85410		
Cure Period	1049 Days			1235 days		
Core I.D.	B	C	G	A	G	H
length (inches)	≈ 3 3/4"	≈ 6"	≈ 5"	≈ 4"	≈ 4-1/2"	≈ 4-1/4"
cracks	none	none	none	none	none	none
surface porosity	minor	minor	minor	minor	minor	minor
core condition	good	good	good	good	good	good
other notes	light grey, chip @ bottom	light grey, chip @ bottom	light grey, chip @ bottom irregular diameter (steps)	light grey, large chip off one end	light grey with dark spots	light grey, dark spots, large chip off one end

TABLE 5
BASELINE EXAMINATION OF CORES ARCHIVED (TYPE V)

	Drum 88124			Drum 88134		
Cure Period	198 Days			393 days		
Core I.D.	A	C	E	B	E	F
length (inches)	≈ 6 3/4"	≈ 7"	≈ 7"	≈ 7 5/8"	≈ 7 5/8"	≈ 7"
cracks	3/32" almost full length	3/32" almost full length	w/raised area	none	none	none
surface porosity	minor	minor	minor	little	little	little
core condition	good	good	good	good	good	good
other notes	medium grey	medium grey	medium grey	light grey, uniform color	light grey, uniform color	light grey, uniform color

	Drum 88114			Drum 88106		
Cure Period	567 days			748 days		
Core I.D.	A	E	G	B	C	E
length (inches)	≈ 4"	≈ 6 1/4"	≈ 3 1/4"	≈ 6"	≈ 4 3/4"	≈ 6 1/4"
cracks	none	none	none	none	none	none
surface porosity	at center	minor	minor	minor	large porosity @ top	minor
core condition	good	good	good	good	good	good
other notes	large chip @ top, lt grey w/ dk grey areas, crumbly bottom	light grey w/ dark grey spots, large posrosity @ center of core	dark grey bottom, porosity @ sides & bottom, crumbly @ end	medium grey, dark spots	med-dark grey marbled, dark spots	medium grey, dark grey spots

TABLE 5 (Continued)

BASELINE EXAMINATION OF CORES ARCHIVED (Type V)

	Drum 88089			Drum 88116		
Cure Period	939 Days			1126 days		
Core I.D.	B	C	G	A	G	H
length (inches)	≈ 4 1/4"	≈ 6"	≈ 7"	≈ 3 1/4"	≈ 8"	≈ 7"
cracks	none	none	none	none	none	none
surface porosity	minor	minor	minor	minor	minor	minor
core condition	good	good	good	good	good	good
other notes	medium grey, wet appearance	medium grey, wet appearance	medium grey, wet appearance	medium grey, with dark spots	dark grey with dark spots and dark streaks	light grey, with dark spots

TABLE 6

SUMMARY OF ARCHIVE CORE EXAMINATIONS: Type I Cement

DRUM NUMBER	DAYS CURED BEFORE CORING	CORE(S) CONDITION	REMARKS
85425	307 days	good	none
85396	503 days	good	none
85499	677 days	good	none
85474	859 days	good	none
85461	1049 days	good	none
85410	1235 days	good	none

TABLE 7

SUMMARY OF ARCHIVE CORE EXAMINATIONS: Type V Cement

DRUM NUMBER	DAYS CURED BEFORE CORING	CORE(S) CONDITION	REMARKS
88124	198 days	good	none
88134	393 days	good	none
88114	567 days	good	none
88106	748 days	good	none
88089	939 days	good	none
88116	1126 days	good	none

TABLE 8

IMMERSION TEST RESULTS
SLUDGE WASH LIQUID CEMENT-WASTE DRUMS

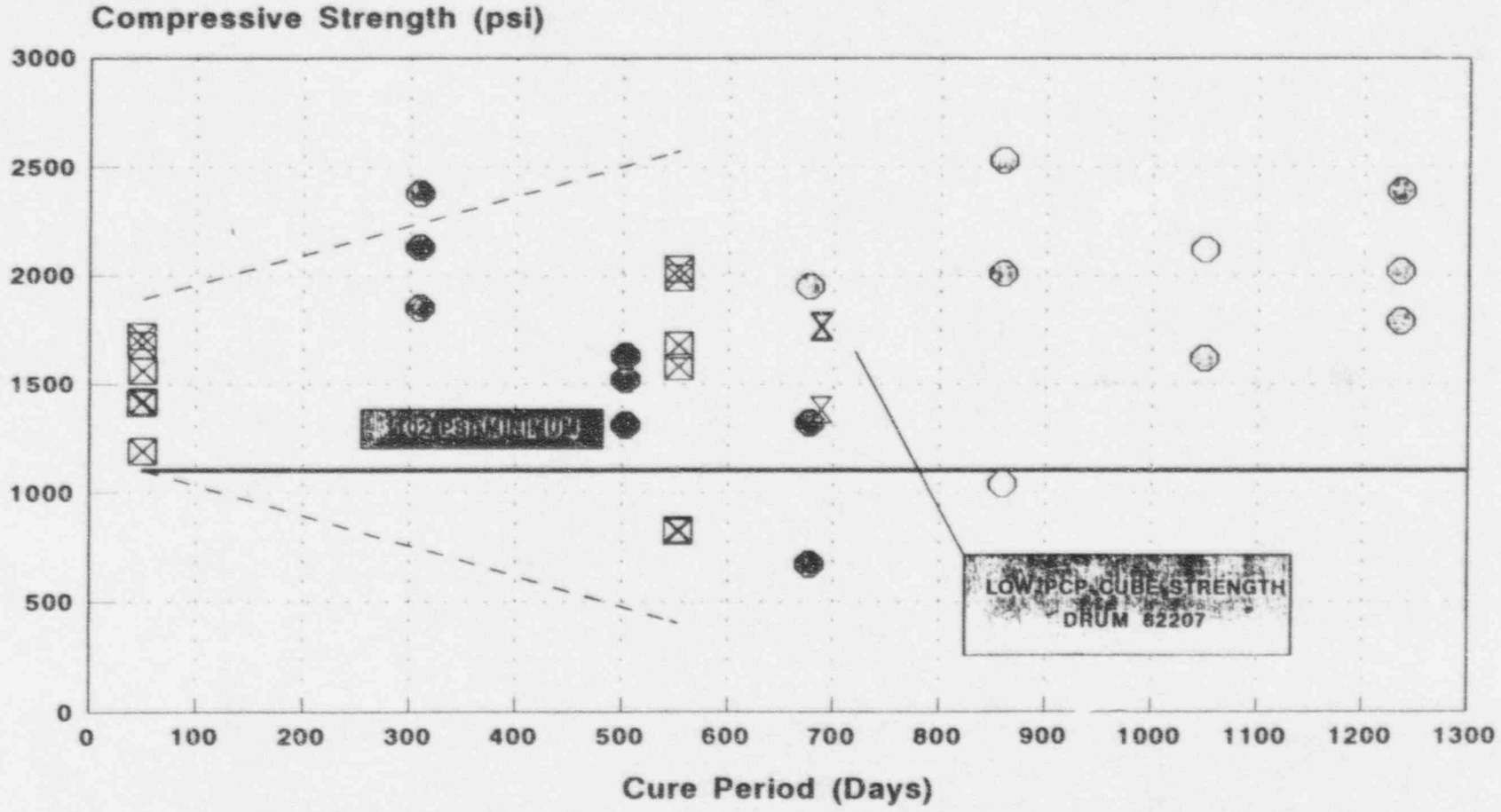
Drum Number	Days Cured	Core & Drum Section	Post-Immersion Compressive Strength (psi)	Comments
85425	348	E-middle	1720 psi	Type I cement
85396	530	F-middle	1770 psi	Type I cement
88124	224	H-top	1100 psi	Type V cement
88134	419	A-bottom	1070 psi	Type V cement

TABLE 9

SPECIAL IMMERSION TEST RESULTS
SLUDGE WASH LIQUID CEMENT-WASTE DRUMS 82207,90435,86764

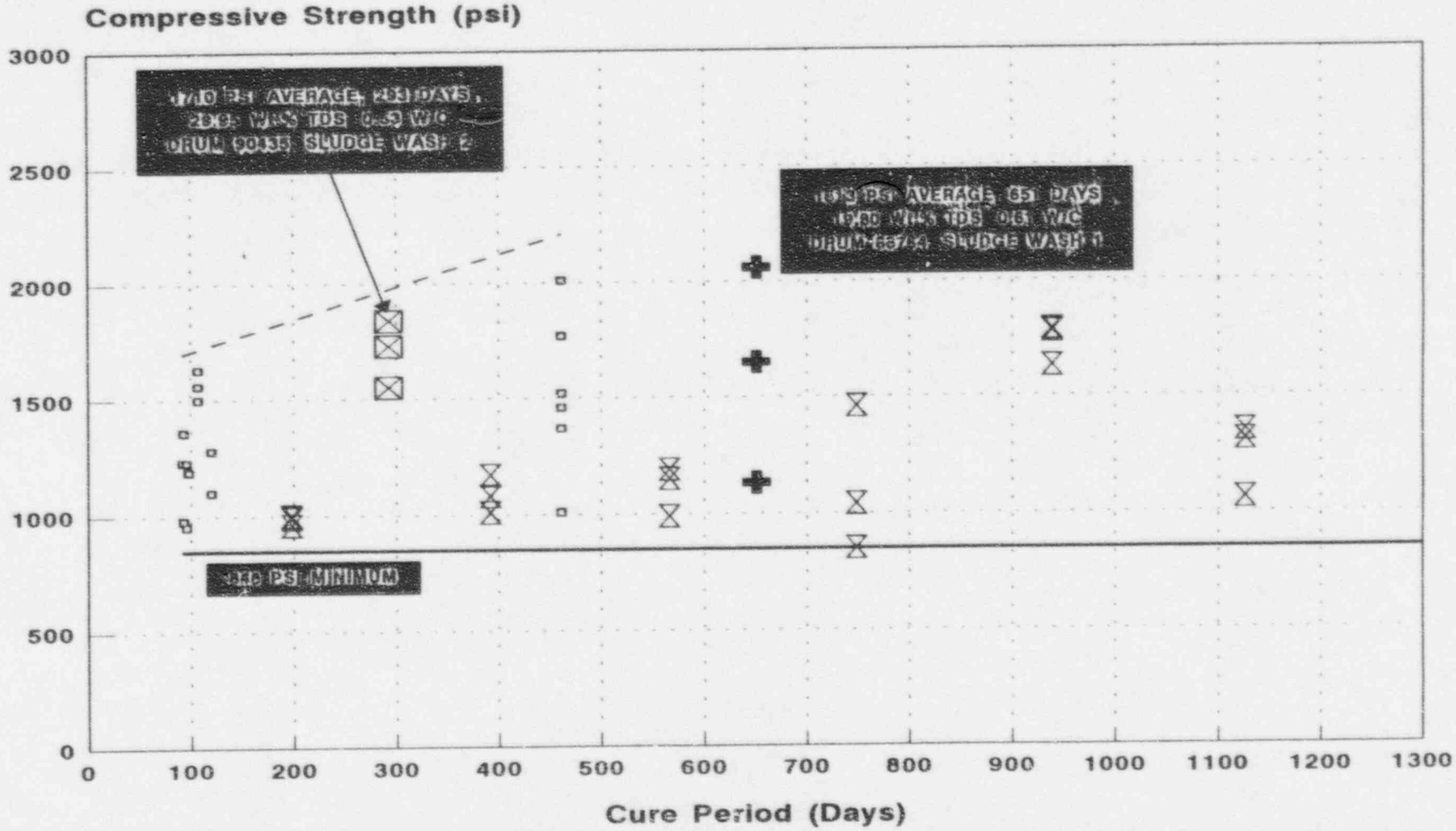
Drum Number	Drum Section	Post-Immersion Compressive Strength (psi)	Comments
82207	Bottom	1980	Type I cement - low compressive strength cube
90435	Bottom	1140	Type V cement - low compressive strength cube
86764	Bottom	970	20% TDS, Type V cement

FIGURE 1
Long Term Compressive Strength
Type I Portland Cement-Waste
20 Wt.% TDS Decontaminated Sludge Wash One



20.57 % TDS, 0.68 W/C QUALIFICATION CORE SPECIMENS ● 20.04 % TDS, 0.67 W/C LONG TERM TEST DRUMS

FIGURE 2
Long Term Compressive Strength Type V Portland Cement-Waste Decontaminated Sludge Wash



▫ 30% TDS, 0.52 W/C QUALIFICATION CORE SPECIMENS

X 32.20 % TDS, 0.51 W/C LONG TERM TEST DRUMS SLUDGE WASH 1